Constraining terrestrial carbon balance through assimilation of remotely sensed biomass data into CARDAMOM

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Differences among Earth System Model forecasts of the carbon cycle are currently significant, and lead to major uncertainties in predictions of the land sink. These differences have been linked to variations in the internal processing of carbon, particularly in the large pools in biomass and soil organic matter. We show here how new remote sensing products, and novel model-data fusion approaches, advance fundamental knowledge of forest ecology and biogeochemistry, and thereby constrain ESMs. Biomass mapping linked to estimates of net primary production provides a constraint on the turnover time of the biomass pool, a critical model parameter. Using the CARDAMOM model-data fusion system, we show how biomass mapping supports improved parameterisation of carbon cycling for ESMs. We identify regional variations in C turnover currently missing from tropical plant functional types. A sensitivity analysis performed using the CARDAMOM system shows a tropical mean 49% reduction of uncertainty of vegetation C turnover time achieved when assimilating the current state-of-the-art pantropical biomass map. This error reduction has clear spatial variability across latitude and between continents. Further, we use CARDAMOM to show how multiple repeated biomass measurements, for instance from ESA's Biomass Mission, reduce bias on estimates of C increment in aggrading ecosystems, and also on internal process parameters like carbon use efficiency. Finally, we show how CARDAMOM analyses can be used to reliably generate an ensemble average of ESM land sink forecasts.